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CONCEPT OF AUTOMATED MACHINING AND INSPECTION IN FMS

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ABSTRACT

Automation is a step beyond mechanization, the correct incentive for applying automation is to increase productivity and to improve the quality. Automation plays an increasingly important role in the world economy and in daily experience. Automation has had a notable impact in the manufacturing industries. Automated manufacturing systems operate in the factory on the physical product. They perform operation such as processing, assembly, inspection, or material handling and sometimes accomplishing more than one of these operations in the same system.

KEYWORDS: Automation, Automated Machining, Inspection, Machine Vision, Pro-E Software, FMS

INTRODUCTION

Chamfering Machine

Burrs are caused by many machining process including milling, drilling, turning, and broaching. Edge finishing like chamfering, blending during manufacturing is important because of the following reasons-

- Sharp edges may pose personal hazardous, since they can cause injuries to worker.
- Part mating may be more difficult due to clearance restriction caused by burrs
- High stress concentration at sharp corners can cause product failures.
- And to enhance part appearance.

Chamfering is performed at the final stage of manufacturing, where parts have their highest added value, quality control is absolute necessity. Despite this requirement, even in today’s most fully automated factories it is still a common sight to see dozens of worker manually chamfered parts produced by CNC machines.

- Edge finishing is typically performed manually using two methods-
- Hand held power tools with brushes, abrasive tips, or rotary files.
- And manual files and knives.

The techniques employed with these tools are not well documented and inspection of these chamfered edges is not quantitatively defined, typically the worker runs the finger over the edge to inspect the work. Improving both the efficiency and quality of chamfering is a major concern. Chamfering is labour intensive and can represents a significant portion of the expense of manufacturing machined parts. In addition, chamfering is frequently a dirty, noisy, and undesirable job and high

turnover in terms of personnel. Training personnel in proper chamfering technique is costly and this, coupled with high turnover rate adds to the overall expense of the chamfering. Variation in skill level of chamfering personnel causes variation in the quality of the part. Errors encountered in the chamfering operation which causes the part to be scrapped are costly, as the part is near the end of its manufacturing cycle. Automatic chamfering operation have been investigated for number of years as a solution to these problem. Chamfering is performed at the final stage of manufacturing, where parts have their highest added value, so inspection is absolute necessity.

INSPECTION

Quality control and part inspection are key processes in the lifecycle of a product. These processes are able to verify product quality; and can provide essential feedback for enhancing other processes. No change is made to product during inspection, in order to increase its value. Time and resources are spent on these processes, without a gain in profit. The reduction of the time spent on these processes is than attractive concept to manufacturer. So, automatic inspection system is developed for chamfer inspection along the edges of the square work part. Automatic inspection system, mainly based on camera- computer technology has been investigated for the sensory analysis of square work part. Computer vision includes the capturing, processing and analysing images. Computer vision systems are largely employed for automatically controlling or analysing processes. Computer vision system benefits from specially designed image processing software to perform such task, therefore image processing plays a very crucial role in their performance. Taking all this facts into account, this thesis will address computer vision and pattern recognition technique and their application on quality inspection of square work part.

The basic operations performed in a digital image processing systems include

- Image acquisition,
- Storage,
- Processing,
- Communication and
- Display.

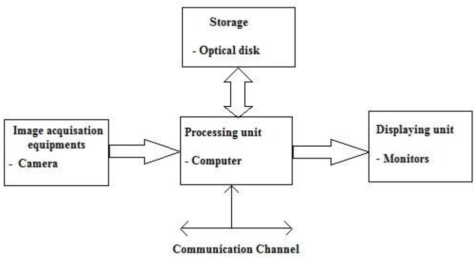

Figure 1: Fundamental Elements of Image Processing

LITERATURE REVIEW

Automation of surface finishing operations such as chamfering, deburring, grinding operation is an active area of investigation in the manufacturing industry. These operations constitute a significant portion of effort and money in manufacturing industry. Research towards automation has focused in many directions from integration of two operations to

development of an intelligent system. Chamfering is performed at the final stage of manufacturing, where parts have their highest added value, so inspection is absolute necessity. Manual inspection is error prone and highly dependence on skill labour. Automatic inspection is best choice in industries, and image processing is increasingly used today. Following are the literature regarding the finishing and inspection operation.

An automatic chamfering for the case of hole on a free curved surface on the basis of CAD data, using an industrial robot. As a chamfered tool, a rotary-bar driven by an electric motor is mounted to the arm of the robot having six degrees of freedom in order to give an arbitrary position and attitude to the tool. The robot control command converted from the chamfering path is transmitted directly to the robot. From the experimental results, the system is found effective to remove a burr along the edge of hole on a work piece with free curved surface [1].

A complete dynamic model that describes the dynamic behavior of the robot for surface finishing tasks is considered. A complete surface finishing task is divided into three phases (free motion phase, transition phase, and constrained motion phase) depending on the location of the robot end-effectors with respect to the constraint surface. Stable control algorithms are developed for each phase. Emphasis is given to the transition phase and constrained motion phase, where surface finishing takes place. In the constrained motion phase, the robot models include both the tangential force that is due to material removal and normal force to keep the robot end-effectors on the surface. By doing this improved performance of the proposed control strategy is occurred when compared with others [2].

To automate the chamfering, an industrial robot is used to handle and hold work piece in front of developed tool station. The tool station is fixed on a worktable has positioning actuators. A file driven by air reciprocating actuators as a chamfering tool. To detect positioning and dimensional errors of work piece, an image of the objective part is taken by camera. The tool station can compensate the errors and chamfer the objective edge based on the calculated positioning information [3].

Using automated path generation, robotic deburring of aero-engine components is done. The core of the system is a set of algorithms capable of fitting and generating the required robot path relative to the feature to be profiled. The incorporation of an MXS sensor and mathematical algorithms allowed precision chamfers to be generated inspire of part tolerances, fixturing errors and robot positional accuracies. The approach developed also eliminates the need for precise location of the part in an expensive fixture and needs only simple low cost clamps to hold the work piece [4].

An automated deburring procedure using a robot manipulator is considered for the removal of burrs in the presence of robot oscillations and bounded uncertainties in the location of the robot end-point relative to the part. Compliant tool holders provide the normal and tangential forces for deburring [5].

In another approach robotic deburring of two dimensional part with unknown geometry covering two problems-tracking the part contour, and control of metal removal process. The tacking control employs the force measured by this force sensor to find the normal to part surface. While the deburring algorithm uses another set of contact force to develop a stable metal removal [6].

An adaptive fuzzy hybrid position/force controller, which can update fuzzy rules to compensate for robot dynamics along with the force dynamics induced by contact between a cutting tool and a part’s edge, and can identify the actual desired contact force in deburring operation[7].

Inaccuracy results from both imperfect sensors and imperfect models of machine, this imperfection may be nonlinear or drift and changes with time, making their prediction difficult. Incorporating sensors like thermocouple, force transducer to aid in the prediction of imperfection or to perform more appropriate measurements, greatly improves the accuracy [8].

Industry needs automated inspection because in manufacturing process uncertainties like defects, orientation error, tolerances etc. exists which can be solved by automated inspection. High speed, high accuracy image processing system is developed for automatic visual inspection of cylindrical parts. This system is realized by original simultaneous processing algorithms which provide both the detection of defects and the development of 2-D image formed from many 1-D signals, obtained through line scan camera grabbing on feed objects directly while they are moving[8].

The development of an Automated Visual Inspection (AVI) system for weaving defect detection based on image processing and recognition algorithms. The neural network approach seems to be an effective tool for classifying the weaving defect [9].

The machine vision system for automatic inspection of defects in textured surfaces has been developed. It aimed to solve the problem of detecting small surface defects which appear as local anomalies embedded in a homogeneous texture of textile fabrics and machined surfaces [10].Computer vision has been for detection of defective packaging of tins of cigarettes by using image processing and morphological operation. The identified objects are used to the defect detective packages in the cigarette packing industries. Algorithm is correctly identifying individual cigarettes and the paper spoons handles in 500 images and then classifying the resulting cigarettes tins as either acceptable or defective[11].

PROPOSED MODEL

Before The model is designed for the computer assisted combined chamfering and inspection system. According to decided dimensions the modeling of the machine is carried out. There are various CAD software's available in the market, some of them are PRO-E, CATIA, SOLID EDGE, IDEAS, AUTOCAD and UNIGRAPHICS.

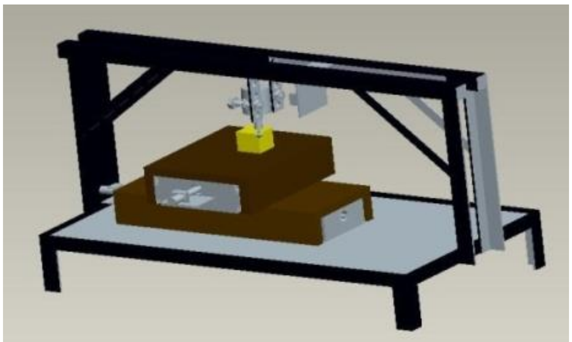

Figure 2: Design of Proposed Model

Selected Fixed gantry type structure is having base plate on which cross feed motion XY table is mounted. A vice is also mounted on the X table for holding the work piece during chamfering operation. Basically the machine incorporates the basic concept of three coordinate axes so that precise movement in x, y directions is possible and in Z direction the movement is kept constant. The tool is coupled with motor and the whole assembly is fixed to the holding plate by nuts and bolts on the body structure. Holes are provided on the holding plate to obtain various depth of cut during chamfering operation. Camera is also mounted on the fixed gantry structure for the inspection purpose.

MACHINE ELEMENTS

Machine elements are basic mechanical parts and features used as the building blocks of machines. For obtaining optimum automation of the system and to acquire high accuracies during chamfering operation, the overall system is carefully designed.

Machine element refers to an elementary component of a machine. These elements consist of three basic types

- Structural components.
- Mechanisms that control movement
- Control components.

The various machine elements of the proposed model are-

Machine structure

Wooden X-Y table assembly

Lead screw

Reciprocating nut on lead screw

Telescopic channels

Bearings

Vice

Couplings

DC motors

- Dc motors for X and Y table
- Dc motor in z direction for tool rotation

Mounting tool

Camera

Microcontroller

Relays

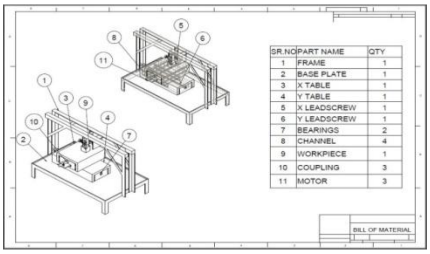

Figure 3: Proposed Model Drafting and Bill of Material

Machine Structure

Use either SI or CGS as primary units. (SI units are The frame structure is the supporting and load carrying member of the system. All the assemblies like X-Y table and tool is mounted on the frame. Angle bar is used to develop the frame structure, the angle bar is made up of steel shaped like an L. One angle is perpendicular to the other. This forms an inside angle as well as an outside angle. Angle bars are then welded to obtain gantry type structure. The frame structure is designed in such a way that it does not deformed or vibrates beyond the permissible limits during the processing.

Figure 4: Base frame

Wooden XY Table Assembly

X-Y tables help to provide horizontal motion for automated system in horizontal X direction and horizontal Y direction. X- Y table is made up of wooden plywood. XY tables are motorized linear slides with linear motion based in bearings which are driven by motors. The X-Y table assembly consists of cross feed lead screw, reciprocating nut assembly, bearings, telescopic channel.

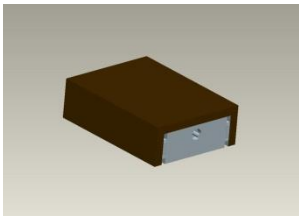

Figure 5: X Table

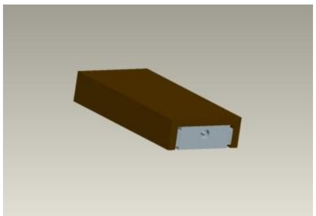

Figure 6: Y Table

Cross Feed Lead Screw

Lead screw translate rotary motion in to linear motion and help to moves the work part in X and Y directions. To obtain proper alignment, lead screw must be in identical size and pitch.

Following Are the Advantages of Lead Screw Are

- Large load carrying capability
- Compact
- Precise and accurate linear motion
- Smooth, quiet, and low maintenance
- Minimal number of part

Telescopic Channels

Telescopic channels are used as slider to move the table. Telescopic channel are mounted on either side of the

wooden block. According to length of travel of the table in either X or Y direction telescopic channels are used. Telescopic channel consists of ball bearings which are useful for obtaining sliding motion. Telescopic channel is made up of zinc coated stainless steel.

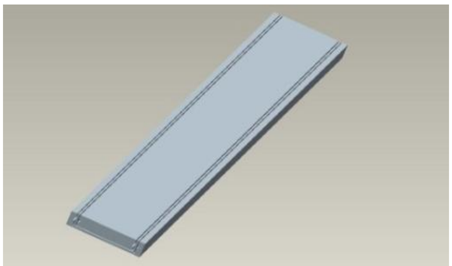

Figure 7: Telescopic Channel

Bearing

A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. The purpose bearing is used to reduce power consumption due to friction resistance and also to avoid rapid wear of lead screw surface. Rolling contact bearing is used here, rolling contact bearing uses spherical balls between stationary and moving elements. Rolling contact bearing can take combination of both radial and thrust load. Rolling contact bearing consists

- Inner race
- Outer race
- Rolling elements
- cage

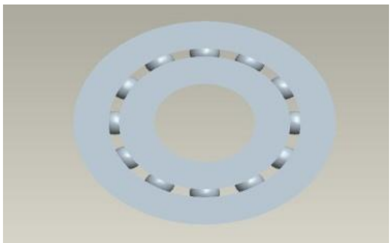

Figure 8: Ball Bearing

Vice

A vice is a mechanical screw apparatus used for holding or clamping a work piece to allow work to be performed on it. Vice usually have one fixed jaw and another, parallel jaw which is moved towards or away from the fixed jaw by the screw. Vice is used for the purpose of grinding square work part. Vice is made up of alloy steel and generally ideal for grinding, light milling and drilling processes.

Coupling

A coupling is a device used to connect two shafts together like motor shaft and lead screw at their ends for the purpose of transmitting power. Flexible couplings are used to transmit torque from one shaft to another when the two shafts are slightly misaligned. It can sustain both lateral and angular misalignment.

DC Motors

Brushed DC motor is used for the tool rotation in Z direction. A DC motor is a mechanically commutated electric motor powered from direct current (DC).Brushed type DC motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets, and rotating electric magnets. The stator is stationary in space by definition. The current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque.

Mounting Tool

Mounting point are used as a tool, for chamfering along the square work part. Mounted points are very small bonded abrasives or super abrasive wheels with a cone shape. They are coupled with motor for chamfering application. For choosing mounting point specification required abrasive grain type, abrasive grain size, grit or grating system, performance parameters, applications, and bond type. Mounted points differ in terms of abrasive grain type and abrasive grain size. Choices for abrasive grain type include aluminium oxide, ceramic, silicon carbide (SiC), alumina-zirconia, synthetic diamond, cubic born nitride (CBN), tungsten carbide, and abrasive grains with a metal layer or coating. There are three main performance specifications for mounted points: rotary speed, shank diameter or bore inner diameter (ID), and outer diameter (OD). Rotary speed is the maximum speed or range recommended by the mounted points designer. Zirconia- alumina is selected as abrasive grain type because-

- More faster cut rate than aluminium oxide
- Reduces vibration and tool chatter
- Two times greater life than aluminium oxide

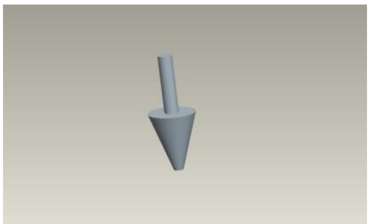

Figure 9: Mounting Tool

Camera

For the inspection purpose, camera is used here. From the camera image is taken and it is used for further analysis. Camera is mounted on fixed gantry structure. Selection and position of camera is important factor for development of system and to obtain accurate image.

Microcontroller

Microcontroller used here is AT89S52. The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

Relays

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal In electromechanical relays the switching element is a mechanical contact, actuated by an electromagnet. This is the most widely used type of relay design. The principal internal functions of the electromechanical relay are:

- Conversion of electrical current (input, coil current) to a magnetic field
- Conversion of the magnetic field into a mechanical force
- This force operates the contacts (secondary side)
- Contacts switch and conduct electrical current (output, load current).

CONCLUSIONS

The review of literature as carried out helps in identification of some potential research regarding the areas of robotic surface finishing operations and automatic non contact inspection of defects. Very little work is done on automatic chamfering system without using robots. It is observed that although several approaches for accomplishing the above mentioned chamfering and inspection tasks have been proposed by researcher in the existing literature, research is required in some critical issues, such as integration of surface finishing and inspection operation on same system.

FUTURE SCOPE

By using this kind of the automation in the flexible manufacturing system saves the time for production and avoid the human error, by using this phenomenon we can apply for other process and it synchronized with the inspection machine for achieving the right time quality product.

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